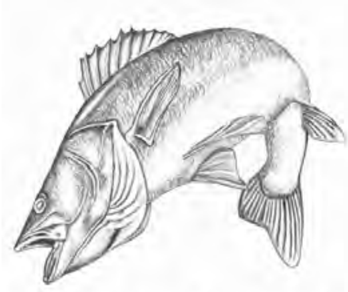


ISU FISHERIES EXTENSION

Managing Iowa Fisheries

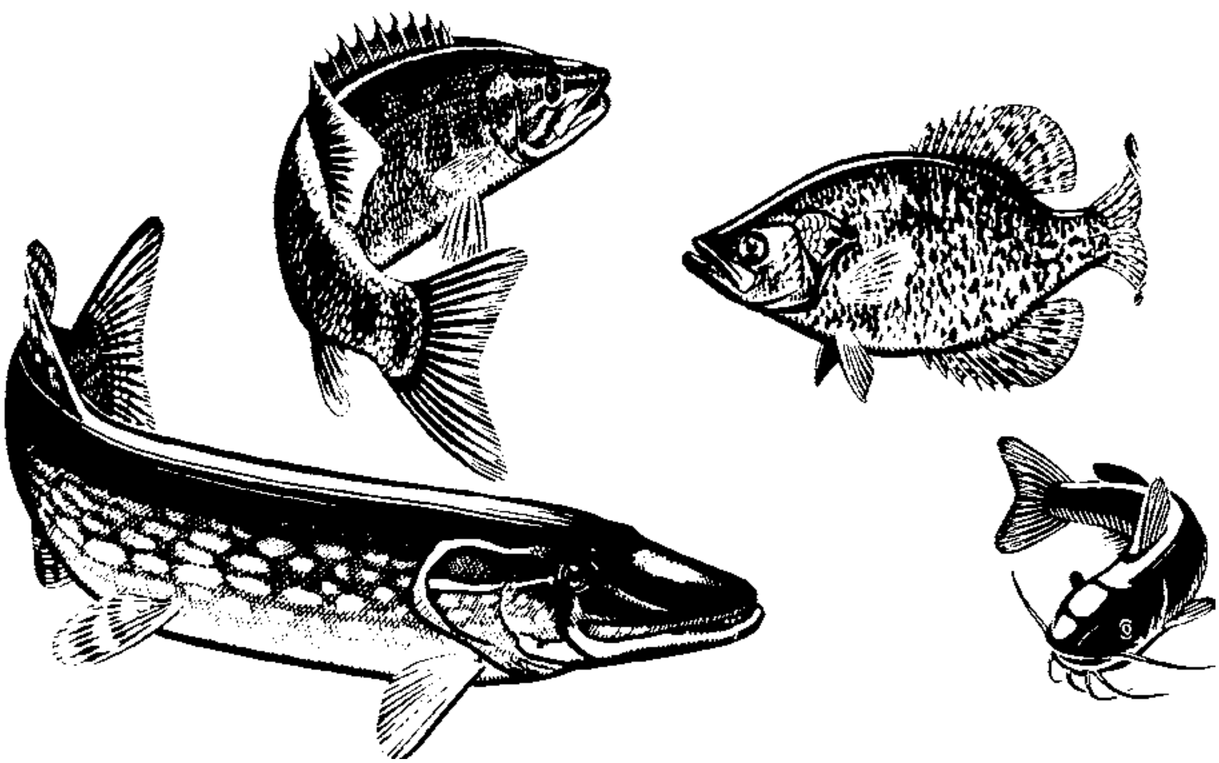
Water Quality

Introduction

Water, the most important component for raising fish, is often the most neglected factor. Fish are totally dependent on water; they derive oxygen from it, ingest it, excrete their wastes into it, absorb and lose salts into it, and are always in contact with it. Poor water quality can cause massive fish kills and is often the major factor contributing to fish diseases. Instead of adding chemicals to the water to treat a disease outbreak, the fish culturist should first look at water quality to determine why the outbreak occurred.

Water quality does not remain constant. In ponds, it can change dramatically over a few hours. Even water from deep wells and springs can change over time. It is not a simple matter for the fish farmer or pond owner to visually assess water quality. The fisheries manager must use chemical tests as well as observations to detect changes.

The purpose of this publication is to assist the fish farmer or pond owner in pond management. For more detailed information on the subject, read *Water Quality Management for Pond Fish Culture*, by Claude E. Boyd (Elsevier Science Publishing Co., Inc., New York). This publication provides a simpler approach to water management and addresses certain aspects of water quality specific to Iowa that are not covered in Boyd's book.



IOWA STATE UNIVERSITY
University Extension

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Chemical Factors

Dissolved Oxygen

Dissolved oxygen is by far the most important water quality factor for fish; fish cannot live without it. Oxygen depletion probably results in more fish kills than all other factors combined. Concentrations of oxygen are expressed as parts per million (ppm) by weight or milligrams per liter (mg/L). The amount of oxygen, as well as many other gases that can be dissolved in water, decreases with higher temperature; at 68°F water can hold 8.8 ppm oxygen, while at 90°F, saturation is at 7.3 ppm. In combining this relationship with the increased demand for oxygen by fish and other organisms at higher temperatures, one can see why summer oxygen depletion is so prevalent. Fish farmers, in an attempt to maximize production, stock a greater biomass of fish in a given body of water than found in nature. As a result, there is a greater demand for oxygen by the fish in production ponds.

Oxygen requirements for fish vary according to species, age, and culture conditions. Most warm water fish require a minimum of 4 ppm and cold water fish require 5 ppm dissolved oxygen for growth, reproduction, and good health. Early life stages usually require greater oxygen concentrations than needed by adult fish. Chronically low dissolved oxygen causes stress, increasing the chance of infectious diseases.

The major sources of oxygen in water are direct diffusion at the air-water interface and plant photosynthesis. There are many oxygen consumers in a pond, including fish, insects, bacteria, and aquatic plants. While plants are oxygen producers during the day, at night they become oxygen consumers. In ponds and lakes, a balance usually exists between oxygen produced and oxygen consumed. A number of things can upset this balance resulting in oxygen depletion and subsequent fish kills. These include the following.

1. Increased organic waste entering the water—Any organic material such as manure from feedlots, septic tanks, and excess fish feed increases the oxygen demand in the water, because the decay process of these materials consumes oxygen.

2. Die-off of aquatic plants—Because aquatic plants are the primary source of oxygen in ponds and lakes, any sudden death, whether by herbicides or natural causes, can result in oxygen depletion. The problem is complicated further by increased oxygen consumption by the decay of this plant material.

3. Excess aquatic plants—Plant growth (especially phytoplankton and submersed plants) during warm months may produce more oxygen than can be held in solution (supersaturation). Oxygen demand by the plants during evening hours is also great resulting in wide fluctuations in dissolved oxygen during a 24-hour period. Reduced light intensity caused by several days of overcast weather limits oxygen production while oxygen consumption remains high. The result is oxygen depletion and fish kills.

4. Temperature stratification of pond water and the eventual remixing (turnover)—This problem is discussed under Physical Factors: Temperature.

Detection of Oxygen Depletion

Oxygen concentrations in a pond usually fluctuate during a 24-hour period; the highest concentration occurs during mid to late afternoon, and the lowest concentration is observed just before dawn. Early morning hours are, therefore, the most critical. An oxygen meter or chemical test kit is the best way to detect dissolved oxygen depletion. Dissolved oxygen concentration should be measured during the late evening or early morning. When this is impractical, it is possible to estimate the potential for oxygen depletion by measuring oxygen in the early evening and again 2 or 3 hours later. Oxygen respiration is considered to be a straight line; therefore, these two values can be plotted on graph paper against time during the remaining hours of darkness to predict the dissolved oxygen at dawn (figure 1).

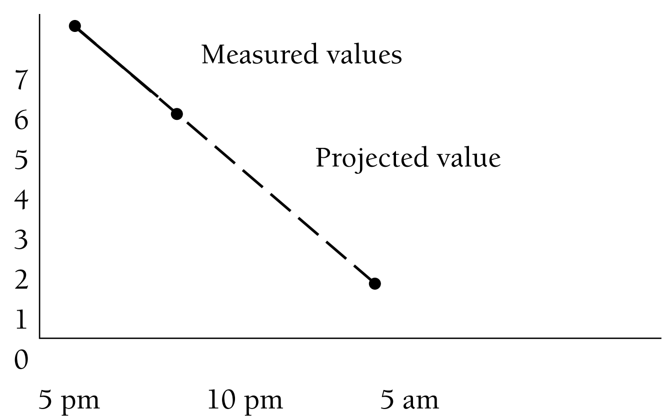

Figure 1. Estimation of potential for dissolved oxygen depletion.

Table 1. Multiplication factors to determine carbon dioxide from pH, temperature, and total alkalinity.*

	41°F	50°F	59°F	68°F	77°F	86°F	95°F
pH	**5°C**	**10°C**	**15°C**	**20°C**	**25°C**	**30°C**	**35°C**
6.0	2.915	2.539	2.315	2.112	1.970	1.882	1.839
6.2	1.839	1.602	1.460	1.333	1.244	1.187	1.160
6.4	1.160	1.010	0.921	0.841	0.784	0.749	0.732
6.6	0.732	0.637	0.582	0.531	0.493	0.473	0.462
6.8	0.462	0.402	0.367	0.335	0.313	0.298	0.291
7.0	0.291	0.254	0.232	0.211	0.197	0.188	0.184
7.2	0.184	0.160	0.146	0.133	0.124	0.119	0.116
7.4	0.116	0.101	0.092	0.084	0.078	0.075	0.073
7.6	0.073	0.064	0.058	0.053	0.050	0.047	0.046
7.8	0.046	0.040	0.037	0.034	0.031	0.030	0.030
8.0	0.029	0.025	0.023	0.021	0.020	0.019	0.018
8.2	0.018	0.016	0.015	0.013	0.012	0.012	0.011
8.4	0.012	0.010	0.009	0.008	0.008	0.008	0.007

*For practical purposes, CO_2 concentrations are negligible above pH 8.4.

When a meter or test kit is unavailable, the following observations and conditions can be used to anticipate oxygen depletion.

1. Fish swim at or near the surface or gulp for air during late night or early morning. Fish may return to deeper water later in the day.
2. Fish suddenly stop feeding.
3. There is a rapid change in water color to brown, black, or gray.
4. A putrid odor arises from the water.
5. There is a loss of algal bloom.
6. There has been an extended period of hot, cloudy weather.
7. There is a heavy summer wind and rain storm.

Carbon Dioxide

All waters contain some dissolved carbon dioxide. Carbon dioxide (CO_2) is an important compound for the growth of plants and may also affect fish health. Aquatic plants and phytoplankton remove CO_2 from the water during daylight hours as part of photosynthesis. Almost all living organisms add CO_2 to the water continuously; at night when photosynthesis stops, plants also add CO_2. Thus, CO_2 fluctuates during a 24-hour period in a manner just the opposite to that of dissolved oxygen.

Changes in CO_2 concentration cause the acidity (see Acidity) of the water to fluctuate during a 24-hour period. When CO_2 is added to water, it forms an acid resulting in a decline of the pH. Conversely, when CO_2 is removed, the pH of the water increases. The presence of carbon dioxide can be a problem when associated with oxygen depletion, but usually is not a problem by itself. When dissolved oxygen is limited, elevated CO_2 levels may interfere with the ability of fish to take up the remaining oxygen. Applying hydrated lime at a rate of 30 to 50 pounds per acre will reduce the CO_2 value in the water by precipitating as calcium carbonate. About 1 ppm hydrated lime is needed to neutralize 1 ppm CO_2. In ponds with very low alkalinities (see Alkalinity and Hardness), care should be taken not to overtreat with hydrated lime, which may cause pH to rise to toxic levels. Ponds with chronically high CO_2 concentrations frequently have high total ammonia concentrations. Treatment with hydrated lime will raise the pH and result in a larger fraction of the total ammonia in the toxic or unionized form, potentially endangering fish (see Ammonia). It should be noted that treatment with hydrated lime does little to alleviate the cause of high CO_2 levels; unless environmental changes are made, CO_2 levels may simply increase again.

The relationship among CO_2, pH, temperature, and alkalinity can be used to calculate CO_2 concentrations. Table 1 can be used to determine CO_2 levels from the pH, temperature, and total alkalinity (ppm $CaCO_3$) of the water. Find the factor in the table that corresponds to the observed pH and temperature, and multiply this factor by the total alkalinity to find the CO_2 concentration. For example, at pH 7.4 and 68°F, alkalinity = 200 ppm as $CaCO_3$. The factor 0.084 is taken from the table, so 0.084 x 200 = 16.8 ppm CO_2.

Generally, waters supporting good fish populations have less than 5 ppm CO_2. Carbon dioxide in excess of 20 ppm may be harmful. If dissolved oxygen content drops to 3 to 5 ppm, lower CO_2 concentrations may be harmful.

Nitrogen

Dissolved nitrogen is not important as long as it remains below 100 percent saturation. However, at supersaturation levels even as low as 102 percent, it can cause gas bubble disease in fish. Gas bubble disease can be caused by any supersaturated gas, but is usually caused by excess nitrogen. Any reduction in gas pressure or increase in temperature can bring nitrogen out of solution and form bubbles; the process is similar to the “bends” in scuba divers. These bubbles can lodge in the blood vessels, restrict circulation, and result in death by asphyxiation. Gas supersaturation can occur when air is drawn in by a high pressure water pump or when air is injected into water under high pressure that is subsequently reduced. Water that is heated or drawn from deep wells is potentially supersaturated. Water that has plunged over waterfalls or dams or is the result of snow melt may also be supersaturated.

Hydrogen Sulfide

Hydrogen Sulfide (H_2S) is a serious problem in fish farming. Incidents of H_2S poisoning are far more common than most fish farmers and biologists realize. Hydrogen sulfide is a colorless, toxic gas with an odor similar to rotten eggs. Hydrogen sulfide kills fish by interfering with respiration.

Hydrogen sulfide is present in the water from wells in certain locations and is present in ponds as a result of bacterial decomposition of organic matter. Fish in ponds usually are affected when crowded in a seine during harvest. Stirring up the black, odoriferous sediments of the pond bottom during seining releases H_2S. Hydrogen sulfide is more toxic to fish at low pH because a greater percentage of the H_2S is un-ionized; raising the pH by liming can result in increased survival of fish.

High temperatures greatly increase the toxicity of H_2S to fish. Fish at 50°F can tolerate five times as much H_2S as compared to tolerable levels at 68°F. During summer months when water temperature may exceed 90°F, an H_2S concentration that would be harmless during winter can cause serious damage.

Well water containing H_2S should be pumped through an aeration device such as a half-open gate valve or slotted cap to help volatilize the toxic gas before it enters the pond. In raceways with acid water and H_2S, abundant aeration should be provided to incoming water. It may help to have water flow over a packed column of oyster shells. Also, the first segment of the raceway should be longer than succeeding segments so that the gas can be volatilized and the fish can detect and avoid the H_2S.

Fortunately, the effects of H_2S are reversible. Potassium permanganate rapidly oxidizes hydrogen sulfide. Therefore, if fish are suffering from H_2S toxicity, the problem can be rapidly alleviated using 2 to 6 ppm potassium permanganate. If water pH is low, the toxicity of H_2S can be reduced by the addition of lime. When seining, bring the net in where there is deep water and very little sediment. Potassium permanganate may be applied to the harvest area to oxidize the H_2S if fish are to be held in the seine for an extended period. Care must be taken in using potassium permanganate because it can be toxic to fish at higher rates.

Acidity

Acidity refers to the capacity of the water molecules to donate hydrogen ions (H). This includes the un-ionized portion of weak acids, such as carbonic acid and tannic acid, as well as salts like ferrous and/or aluminum sulfate. The standard measure of acidity is pH with the pH scale ranging from 1 to 14; the lower the number the greater the acidity. A pH value of 7.0 is neutral. Fish are able to live in waters within a pH range of about 3.5 to 10.0, but the desirable range for most fish is generally considered to be from 6.5 to 9.0. Fish have less tolerance of pH extremes at higher temperatures. Ammonia toxicity becomes an important consideration at high pH (see Ammonia), and hydrogen sulfide is more toxic at low pH.

The pH of pond water is influenced by the amount of carbon dioxide present. Much of the CO_2 present is the result of animal and plant respiration. Carbon dioxide is used during photosynthesis; therefore, CO_2 concentrations in water increase at night and decrease during daylight hours. Since CO_2 in water is an acidic substance, the pH of water is usually highest in the late afternoon and lowest just before sunrise.

The amount of the daily pH fluctuation is somewhat dependent on the buffering capacity of the water. Adding agricultural lime to a pond increases the bicarbonate buffering capacity of the water. This generally increases morning and lowers afternoon pH values, thus lessening daily changes.

Accurate measurements of pond water pH are best determined on site. The pH of water may change during the interval between sampling and determination in the laboratory. Various companies manufacture field test kits and meters for measuring pH. For an accurate measurement of daily changes in pH, pond water should be sampled during early morning and late afternoon hours.

Alkalinity and Hardness

Alkalinity and hardness are similar but they represent different types of measurements. Alkalinity refers to the capacity of the water to accept hydrogen ions and is the direct counterpart of acidity. The anions (negatively charged) or bases involved are mainly carbonate (CO_3^{2}), bicarbonate (HCO_3), and hydroxide (OH); alkalinity refers to these in terms of equivalent concentrations of calcium carbonate ($CaCO_3$). Originally, the hardness of any water was the measure of the capacity of the water for precipitating soap. Soap is precipitated chiefly by calcium and magnesium ions, but also may be precipitated by ions of other metals, such as aluminum, iron, manganese, strontium, and zinc, and by hydrogen ions. Sometimes the amount of hardness is numerically greater than the sum of the carbonate and bicarbonate alkalinities. Hardness equivalent to the total alkalinity is called "carbonate hardness." Hardness in excess of total alkalinity is called "noncarbonate hardness." Hardness, like alkalinity, is also expressed as $CaCO_3$, equivalent concentration. Many authors incorrectly use the term "hard water" to refer to water with high alkalinity. Most waters of high alkalinity are hard waters, but this is not always true. Fish culturists often place undue emphasis on the total hardness of water. Total hardness is usually not nearly as important as total alkalinity in pond fish culture.

Fish grow under a wide range of alkalinity and hardness. Natural waters that contain 40 mg per liter or more total alkalinity are considered more productive than waters of lower alkalinity. The greater productivity does not result directly from alkalinity, but rather from phosphorus and other nutrients that increase along with total alkalinity. In fertilized fish ponds, total alkalinity values in the range of 20 to 120 mg per liter have little effect on fish production. However, in fertilized ponds containing less than 20 mg per liter total alkalinity, fish production tends to increase with increasing alkalinity. At low alkalinity, water may lose much of its ability to buffer against changes in acidity, and pH may fluctuate. Even when alkalinity is zero, if weak acids such as tannic acid are present, they may accept hydrogen ions, thereby buffering changes in pH. Fish also may be more sensitive to some toxic substances such as copper at low alkalinity.

Determination of water hardness and alkalinity can either be made on site with water test kits or by submitting a sample for analysis to a laboratory. Agricultural (dolomitic) lime is recommended for increasing alkalinity. Table 2 can be used as a guide for liming; however, it is difficult to overlime a pond.

Table 2. Quantity of dolomite needed for ponds of varying alkalinity.

Total alkalinity	Dolomitic lime/surface acre
12 ppm or less	1 ton
12-14 ppm	¾ ton
15-25 ppm	¼-½ ton
25 ppm or more	None

Ammonia

Ammonia is excreted into the water by fish as a result of protein metabolism. Some of the ammonia reacts with water to produce ammonium ions, and the remainder is present as un-ionized ammonia (NH_3). Un-ionized ammonia is much more toxic to fish than ammonium. Standard analytical methods do not distinguish between the two forms, and both are lumped as total ammonia. The fraction of total ammonia that is un-ionized ammonia (NH_3) varies with salinity, dissolved oxygen, and temperature, but is determined primarily by the pH of the solution. For example, an increase of one pH unit from 8.0 to 9.0 increases the amount of un-ionized ammonia approximately 10-fold. These proportions have been calculated for a range of temperatures and pH values and are given in table 3. Note that the amount of NH_3 increases as temperatures and pH increase. To calculate the un-ionized ammonia, determine the percentage from the table by using the measured pH and temperature values. Un-ionized ammonia (ppm) = (ppm total ammonia x percentage of un-ionized ammonia) per 100.

Table 3. Percentage of total ammonia that is un-ionized at varying pH and temperature.

	54°F	62°F	68°F	75°F	82°F	90°F
pH	**12°C**	**16°C**	**20°C**	**24°C**	**28°C**	**32°C**
7.0	0.21	0.30	0.40	0.52	0.70	0.95
7.2	0.34	0.47	0.63	0.82	1.10	1.50
7.4	0.54	0.74	0.99	1.30	1.73	2.36
7.6	0.85	1.17	1.56	2.05	2.72	3.69
7.8	1.35	1.84	2.45	3.21	4.24	5.72
8.0	2.12	2.88	3.83	4.99	6.55	8.77
8.2	3.32	4.49	5.94	7.68	10.00	13.22
8.4	5.15	6.93	9.09	11.65	14.98	19.46
8.6	7.93	10.56	13.68	17.28	21.83	27.68
8.8	12.01	15.76	20.08	24.88	30.68	37.76
9.0	17.78	22.87	28.47	34.42	41.23	49.02
9.2	25.53	31.97	38.69	45.41	52.65	60.38
9.4	35.20	42.68	50.00	56.86	63.79	70.72
9.6	46.27	54.14	61.31	67.63	73.63	79.29
9.8	57.72	65.17	71.53	76.81	81.57	85.85
10.0	68.40	74.78	79.92	84.00	87.52	90.58
10.2	77.42	82.45	86.32	89.27	91.75	93.84

The amount of un-ionized ammonia that is detrimental to fish varies with species. Growth rate of trout declines and damage to gill, kidney, and liver tissue is evident at 0.0125 ppm un-ionized ammonia. Reduced growth and gill damage occur in channel catfish exposed to levels greater than 0.12 ppm un-ionized ammonia. Critical levels of un-ionized ammonia have not been determined for many aquaculture species. Chronic exposure to low levels of un-ionized ammonia may stress fish, increasing the chance of infectious diseases.

Nitrites

Nitrite (NO_2), the intermediate product of the oxidation of ammonia to nitrate, also is toxic to fish. Nitrite enters the blood of fish across the gill membranes and combines with the oxygen-carrying portion of red blood cells (hemoglobin) to form a compound called methemoglobin that cannot carry oxygen. Methemoglobin has a brown color, which it imparts to the blood of fish suffering from nitrite poisoning, hence the name "brown blood disease." Because nitrite interferes with oxygen uptake by the blood, the symptoms of nitrite poisoning are quite similar to those caused by oxygen depletion, except that the symptoms persist throughout the day.

The nitrite concentration that is toxic to fish depends on the species of fish, the amount of chlorides (Cl-) present in the water, and the quantity of dissolved oxygen. Rainbow trout are stressed at 0.15 pp. nitrite and killed by 0.55 ppm. Channel catfish are more resistant to nitrite, but 29 ppm can kill them. Nitrites are usually not a problem if there are three or more parts of chlorides present in the water for every part of nitrite. Chlorides do not affect the amount of nitrite in the water, but prevent the uptake of nitrite by the blood of the fish. Any time there is 0.1 ppm or more nitrites present, the water should be checked for chlorides to see if salt should be added. The addition of 25 ppm salt (NaCl) for each ppm nitrite has proven to be an effective treatment. A freshwater flush also is recommended to reduce nitrites.

Physical Factors

Temperature

Temperature has a direct effect on fish metabolism, feeding, and survival. No other physical factors affects the development and growth of fish as much as water temperature. Metabolic rates of fish increase rapidly as the temperature rises. Conversely, as temperature decreases, so does the fish's demand for oxygen and food. Many biological processes, such as spawning and egg hatching, are geared to annual changes in environmental temperature. Each species of fish has a temperature range it can tolerate; within that range, there is an optimum temperature for growth and reproduction, which may change as the fish grows. Like fish, disease organisms also have an optimum temperature range for development, and outbreaks are more prevalent during these conditions. Most chemical substances dissolve more readily as temperature increases; in contrast, gases such as oxygen, nitrogen, and carbon dioxide become less soluble as temperature rises.

Large, rapid changes in temperatures are stressful to fish and may result in death. This problem is most important when fish are transported for stocking. Prior to stocking, water in the transport container should be tempered with the water in which the fish will be stocked. For small sensitive fry, a temperature rate of 3.6°F per hour is suggested. Larger more hardy fish can withstand more than a 9°F per hour change in temperature. Tropical fish species can generally tolerate an increase in water temperature better than a decrease. The opposite is true for temperate and cool-water species. Fish that initially survive a temperature shock may be sufficiently stressed to later succumb to infection.

Temperature has an indirect effect on the fish as a result of water stratification. As temperature changes, so does water density. The temperature at which water is at its maximum density is 39.2°F. In early spring, pond water temperature is uniform from surface to bottom. As the days become warmer, the surface water becomes warmer and lighter. By early summer, the pond may become stratified into three layers: (1) the upper oxygen-rich, warmer layer called the epilimnion; (2) the transition layer or thermocline, which is characterized by a rapid change in temperature; and (3) the lower, oxygen-poor, cooler layer called the hypolimnion. The density difference of the water in these layers resists mixing. In temperate regions, the differences in temperature between these layers may become quite pronounced. Temporary stratification and turnover may occur many times during the summer as a result of strong winds and rains.

Turnover can cause water quality problems because the lower layer usually contains decaying organic matter, little oxygen, and toxic products of decomposition. The signs of summer turnover are a rapid change in water color to a brown, black, or gray, a putrid odor, and fish gulping at the surface. These symptoms are usually observed after periods of heavy wind and rain. Turnover also may occur with the loss of a phytoplankton bloom resulting in increased sunlight penetration, warming the water to greater depth.

In small ponds and lakes, stratification can be prevented by routine use of mechanical aerators to maintain constant mixings. This procedure results in more constant dissolved oxygen concentration at all levels and helps to prevent the succession of algae from the desirable greens to undesirable blue-greens.

Winterkill

Shallow, productive Iowa lakes and ponds may suffer from winterkill. Winterkills result in lower winter dissolved oxygen levels and diminished populations of many sport fish the following spring.

Managing lakes that winterkill may involve removal of all vulnerable fish before the onset of winter, followed by supplemental stocking or pond renovation in the spring. However, in order to more fully address the causes of winterkill, the landowner should restrict nutrient flow into the pond, increase pond depth, or install aeration devices.

Lake aeration may take place in summer, fall, or winter. Fall or summer aeration reduces the amount of decomposing organic wastes that results in decreased oxygen demand in the winter. Winter aeration may be dangerous due to the resulting hazardous opening in the ice or management practices during inclement weather.

Aeration devices come in a variety of forms and prices. It is important to match a suitable aeration device to the appropriate pond size to maximize aeration. Numerous publications are available that list sizes and prices of aerators.

Turbidity

Turbidity refers to the amount of suspended solids in the water that hinders light penetration. Turbidity can be the result of planktonic algae (green water) or clay particles in suspension. Although turbidity does not usually affect the fish directly, clay turbidity limits light penetration and may result in less productive waters. Planktonic algae, however, are desirable because these microscopic plants provide the basis for the food chain for the entire pond, resulting in increased fish production.

Most clay turbidity problems are the result of exposed soil in the watershed, crayfish, bottom-feeding fish such as carp and catfish, or livestock wading in the pond. Newly constructed ponds also may have clay turbidity problems.

Ponds that remain turbid for long periods of time should be treated. The following treatments are only temporary. Therefore, the source of turbidity should be eliminated before treatment. Before using one of these treatments, be sure that the turbidity is caused by clay suspension and not by phytoplankton, which can look quite similar. Microscopic examination is required to distinguish clay turbidity from planktonic algae.

1. 80 pounds per acre-foot (1 acre-foot = 1 surface acre 1 foot deep) of commercial alum. To avoid pH reduction and possible fish kill, simultaneously apply 30 pounds per acre-foot of hydrated lime.

2. 300 to 500 pounds per surface acre of gypsum (land plaster).

3. 7 to 10 small bales of hay and 40 pounds superphosphate per surface area.

Avoid the last treatment during the summer because oxygen depletion may result. Effectiveness of any treatment is determined by degree of turbidity.

Fertilization

Adding fertilizer to pond waters stimulates the growth of phytoplankton (green water) and small aquatic invertebrates (zooplankton and insects) that feed on the phytoplankton, thus improving the growth of the fish that feed on the invertebrates. A fishery biologist should be consulted before recreational ponds and lakes are fertilized. **Most lakes and ponds in Iowa are already fertilized with nutrients from the surrounding watershed and should not be fertilized further by the pond owner.**

Fertilization of production ponds is complex and rates vary among locations and from pond to pond. Before starting a fertilization program, the water should be tested for nutrients, similar to a soil test before planting a crop. The objective is to maintain a phytoplankton bloom of a density that allows the pond owner to observe a light-colored object at a depth of approximately 18 inches. This can be determined by attaching a pie plate to a yardstick, or more simply by extending your arm down into the water; you should be able to see your hand down to slightly over elbow depth. You may need to add fertilizer every week or two to maintain the bloom. Liquid fertilizer (ammonium polyphosphate) may be more efficient for pond fertilization than granular forms. Rates of fertilization should start at 1/2 to 1 gallon per acre and then be adjusted for your particular conditions. Fertilization should begin when water temperature warms to 70°F, and stopped towards the end of September when water temperatures fall under 70°F.

To prevent undesirable blue-green algal blooms, nitrogen should be added every time phosphorus is used. By using liquid fertilizer, this is accomplished automatically. Blue-green algae also may be prevented by adding organic material such as hay, manure, and cottonseed meal with the inorganic fertilizer. This treatment should not be used during hot weather because of the risk of oxygen depletion.

Summary

In conclusion, it is important to remember that water quality does not remain constant and therefore must be monitored frequently.

The various water quality factors are interrelated. A change in pH can affect the toxicity of ammonia, hydrogen sulfide, and carbon dioxide. Hydrogen sulfide and carbon dioxide are a greater problem when dissolved oxygen is low. Changes in temperature affect the toxicity of ammonia and hydrogen sulfide, the amount of dissolved oxygen present, and the potential of nitrogen supersaturation.

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